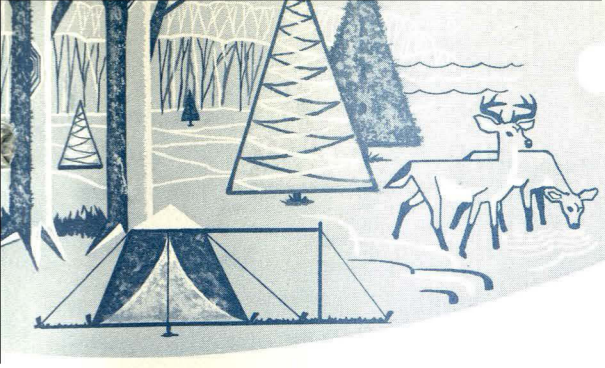

U. S. FOREST SERVICE

RESEARCH NOTE NC-43

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

Folwell Avenue, St. Paul, Minnesota 55101

Buildup Index as an Expression of Moisture Content in Duff

ABSTRACT.—The relation between Buildup Index and moisture content of grouped litter and duff samples from beneath four medium-site forest stands closely approximated the relation between Buildup Index and moisture equivalent of 5-day timelag fuels having an equilibrium moisture content of 15 percent.

Moisture content is one of the most important factors affecting the rate at which forest fuels will burn. Generally, moisture content varies with weather conditions, but it also varies with volume and compactness of the fuels and whether they are green or cured.

The Buildup Index of the National Fire Danger Rating System, a cumulative numerical index derived from daily weather data, presumably indicates the moisture content in medium-drying forest fuels. Buildup Index is a component of Spread Index and is often used separately for fire control planning.[1] The fuels to which Buildup Index primarily applies are forest litter (L) and duff (F) averaging 3 to 4 inches in depth.[2] The amount of moisture in these forest floor fuels largely determines how deep a fire will burn and is therefore particularly useful for predicting the effects of both wild and prescribed fires.

During 1963, we compared the Buildup Index with the actual moisture content of forest floor fuels commonly found in the Lake States to see how consistently it predicted fuel moisture. Samples of litter and duff from well-stocked pine and hardwood stands were collected between 1:00 p.m. and 2:30 p.m. on 56 irregularly scheduled days from mid-May to mid-August. On each scheduled day, one composite L and F sample was collected from five randomly located plots in each of four medium-site stands. Three stands—45-year-old and 90-year-old natural red pine and uneven aged aspen-oak — were in northern Minnesota. The fourth—a 25-year-old red pine plantation—was near Cadillac, Mich. The 90-year-old red pine stand and the aspen-oak stand had an understory of hazel brush and herbaceous vegetation and a well-developed[3] forest floor. The 45-year-old red pine stand also had a well-developed forest floor but very little subordinate vegetation. The 25-year-old red pine plantation had a shallow, poorly developed floor and no understory vegetation.

The moisture content of the samples was determined by ovendrying. For each sampling date the Buildup Indexes were computed from data taken daily at 1:00 p.m. with

---

[1] *Ralph M. Nelson. The National Fire Danger Rating System. U.S Forest Serv. Res. Pap. SE-13, 44 p. Southeast. Forest Exp. Sta., Asheville, N. C. 1964.*

[2] *U.S. Forest Service. National Fire-Danger Rating Handbook, FSH2-5123.3. Feb. 1964.*

[3] *Litter, duff, and humus present and readily identifiable.*

hygrothermographs and recording rain gauges near the sampling areas.

The highest Buildup Index computed during the sampling period in northern Minnesota was 53, at which time the average fuel moisture was 15 percent in the 45-year-old pine and 36 percent in the aspen-oak and 90-year-old pine stands. At the Michigan site the highest Buildup Index computed was 107; the average fuel moisture at that time was 18 percent.

There was no significant difference in the mean values and rates of change for the fuel moisture-Buildup Index relationship between

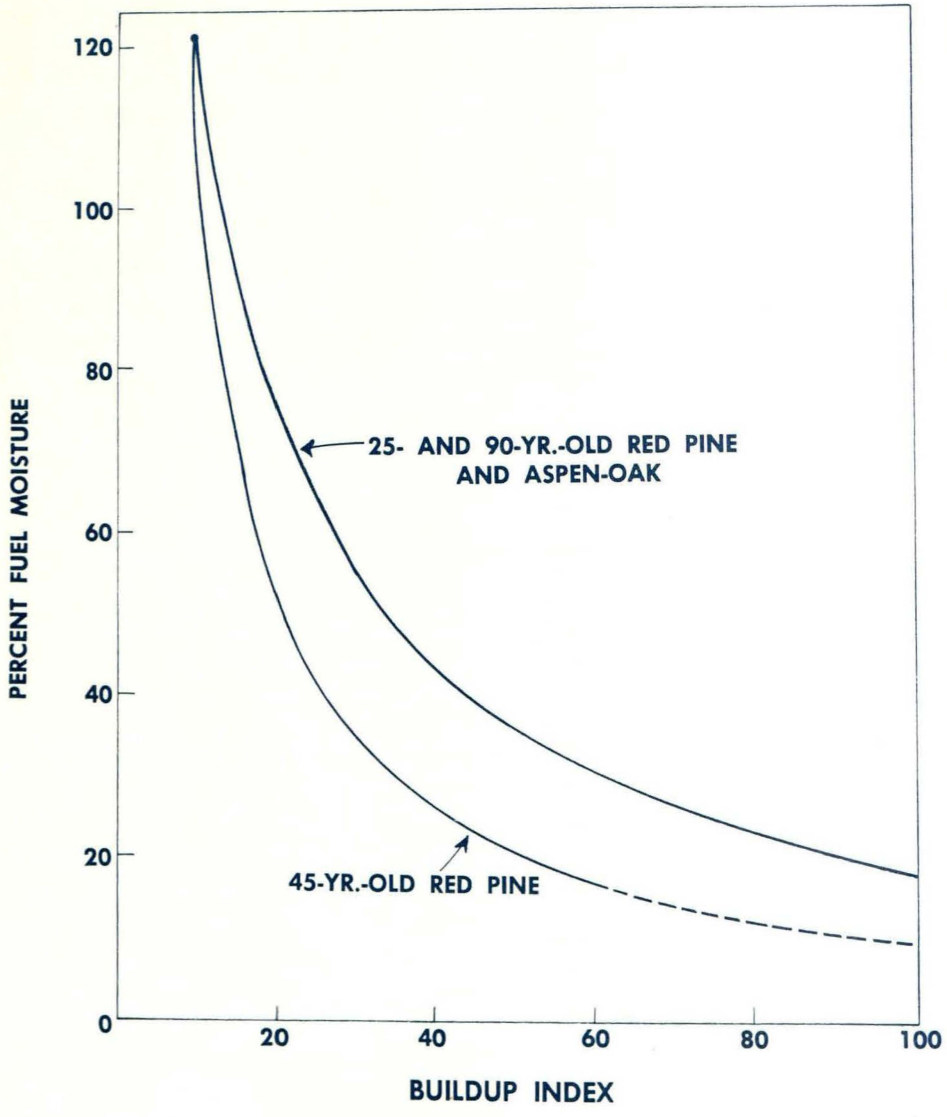

Figure 1.—Buildup Index (BUI) compared to moisture content (MC) of duff. The equations for the trend lines are:

25- and 90-year-old red pine and aspen-oak:

$1/\%MC = .0032 + .0005\ BUI.$ $r^2 = .45$, $N = 91$

45-year-old red pine:

$1/\%MC = -.0006 + .0010\ BUI.$ $r^2 = .46$, $N = 35$

The broken line for the 45-year-old red pine indicates a projection beyond the limit of the field data.

the hardwood and the 25- and 90-year-old pine stands. These data were therefore grouped and plotted separately from those for the 45-year-old red pine (fig. 1). The more rapid change in fuel moisture in 45-year-old pine duff with changes in the Buildup Index is more apparent than real. This response was partially due to the absence of understory vegetation and less compact litter.

Grouped data from all four stands did not compare favorably to the fuel moisture equivalent of 10-day timelag[4] fuels from which Buildup Index was derived[5] (fig. 2). However, the data closely approximated the fuel moisture equivalent of 5-day timelag

[4] *Timelag is the interval of time required for a fuel, under standard drying conditions where the dry bulb temperature is 80° F. and the wet bulb temperature is 57° F., to lose approximately two-thirds of its moisture content above equilibrium.*

[5] *John J. Keetch. Development of the National Fire-Danger Rating System: Basic Structure and Spread Phase. U.S. Forest Serv., Southeast. Forest Exp. Sta., Asheville, N. C. 1965. Unpublished report.*

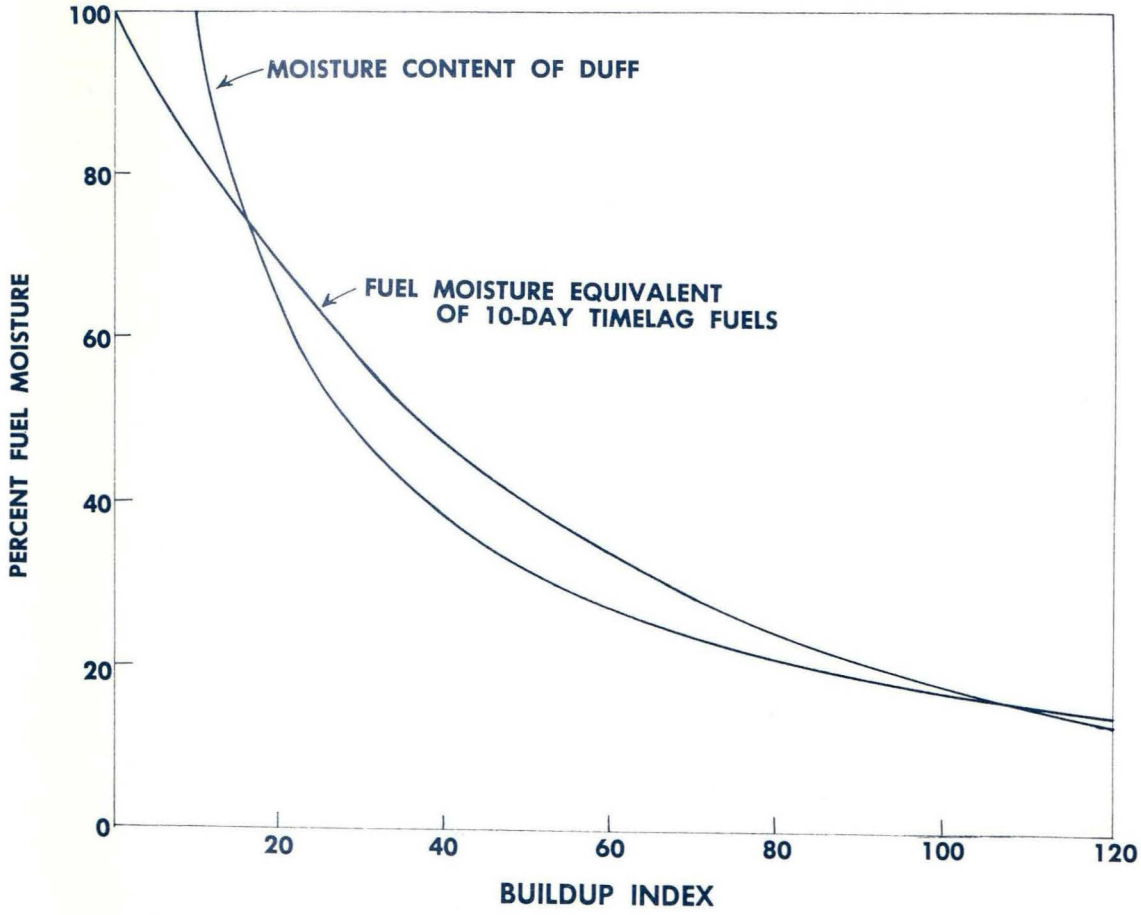

Figure 2.—(1) The moisture content (MC) of duff compared to the (2) fuel moisture equivalent of 10-day timelag fuels (see text footnote 5 for source of data) when both are plotted over Buildup Index. The equations for the trend lines are:

(1) $1/\%\ MC = .0047 + .00053\ BUI.$ $\quad r^2 = 36,\ N = 126$

(2) $MC = (100 - 5) \ / \ \left[(2.71825)^{\frac{BUI}{50}}\right] + 5$

fuels having a saturated moisture content of 145 percent and drying to an equilibrium moisture content of 15 percent.

This study did not establish that there is a reliable relationship between the full range of litter and duff moisture and the higher values of Buildup Index. The equation for 25- and 90-year-old red pine and aspen-oak (fig. 1) may be used, however, in similar stands as an indicator of the trend in moisture content of litter and duff fuels during late spring and summer. The indicated relationship becomes less reliable as the litter and duff approach the estimated 15-percent equilibrium moisture.

We still do not know precisely what fuel moisture levels are needed for controlled fire to remove specific quantities of forest floor material, nor do we know how various physical and chemical characteristics of fuel influence fuel moisture. Continued use of Buildup Index and fine fuel moisture[6] for describing burning conditions will, however, strengthen our understanding of the relationship between fuel moisture and fire effects.

[6] *Table 1.—Fine Fuel Moisture. U.S. Forest Serv. Form 5100-24 (2/64).*

1968

VON J. JOHNSON
Principal Fire Control Scientist